Outage Performances of 5G Channel Model Considering Temperature Effects at 28 GHz

Matsna Nuraini Rahman and Khoirul Anwar
Center for Advanced Wireless Technologies (AdWiTech), Telkom University,
Jl. Telekomunikasi No. 1, Terusan Buah Batu, Bandung, 40257 INDONESIA
E-mail: {matsna@student., anwarkhoirul@}telkomuniversity.ac.id

***Abstract*—The 5th telecommunication generation (5G) is expected to be deployed worldwide in 2020 including Indonesia for future better services using 1-100 GHz band, which is sensitive to the environments. For optimal 5G deployment in Indonesia, this paper studies 5G channel model based on software simulation by considering the influence of temperature, where Telkom University, Bandung, Indonesia, is chosen as a representative location for the 5G channel model. We consider a frequency of 28 GHz, which is one of the golden frequencies for pratical 5G applications. From the model, we obtain Power Delay Profile (PDP) representing the 5G Telkom University channel model. Based on the PDP, this paper calculates the outage performances to predict the 5G performance of Indonesia regardless any 5G technologies used, since the outage performance is based on the theoretical Shannon channel capacity limit for a probability of error asymptotically small (close to zero).**

***Index Terms*—5G Channel Model, Temperature, Power Delay Profile, Outage Probability, Capacity.**

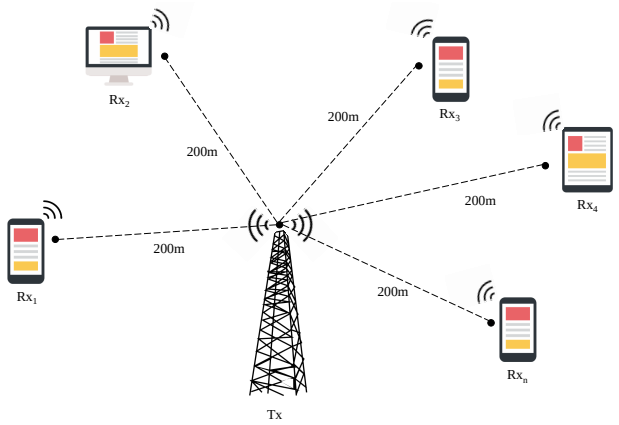


Fig. 1. Structure for Telkom University 5G channel modeling.

I. Introduction

Indonesia's weather conditions, temperature, and environment are unique due to changing of atmospheric conditions in the same place, causing 5G channel models of Indonesia are different from channel models in other countries [1]. This paper focuses on the effect of temperature changes occurring over the specified range and place, where Telkom University, Bandung, Indonesia, is chosen as a representative location for the 5G channel model. Since Indonesia is a tropical country having maximum and minimum temperature, which is quite extreme, understanding and calculating channel model with temperature effects on propagation is very useful in order to design an optimal communication system [2]. When the model channel in a country is known, then parameter for machine can be set to produce maximum capacity and system performance for that country.

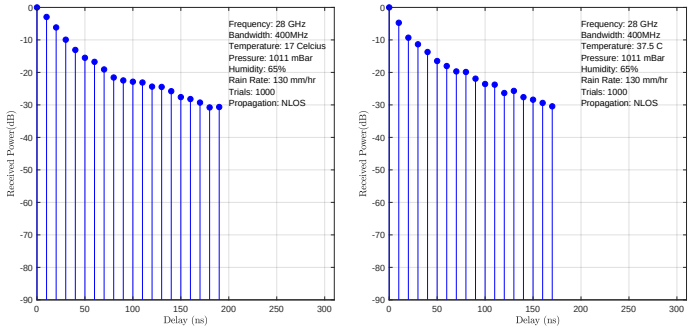
This paper proposes 5G channel model based on software simulation by considering the influence of temperature to calculate the power delay profile with real-field environmental parameters including barometric pressure, humidity, and temperature parameters. There are 1000 probabilities of power delay profile (PDP) in every conditions which is evaluate to have representative PDP in Telkom University with cumulative distribution function (CDF) method. Based on the representative PDP, this paper calculates capacity and generates outage probability used to design the 5G channel model with temperature effect of Indonesia, especially Telkom University.

This research is supported in part by the INSINAS Riset Dikti Funding under the 5G-POINT project, 2018-2019

II. System Model

Indonesia belongs to a sub-tropical known as extreme weather that is currently unpredictable. We used data from Badan Meterologi, Klimatologi, dan Geofisika (BMKG) for 12 months to obtain maximum and minimum temperature. Fig. 1 shows structure of communication considering 1 transmitter and 1000 receiver locations with omnidirectional antenna. This paper only examines the channel model at 200 m between transmitter and receiver, which is assumed as the center distance of the 5G communication range. This paper considers frequency $f_c = 28$ GHz and bandwidth $B = 400$ MHz based on the specification of orthogonal frequency-division multiplexing (OFDM) numerology three [3], where the regulation from the ministry of communication and informatics of Indonesia about broadband wireless access in Indonesia [4] is taken into account.

From the simulation and measurement, we obtain the data of PDP for maximum and minimum temperature (on each condition). Capacity for broadband channel is then calculated from PDP. After that, the outage performance of 5G implemented



a. b.

Fig. 2. Representative PDP with a. maximum temperature and b. minimum temperature effects of Telkom University.

can be obtain for each observed rate, we use $R = 0.5$ and $R = 1$.

III. The Proposed Framework

First, we collect a realfield parameter of environment in Telkom University, Indonesia as a simulation area. Second, we generate the instantaneous PDP from New York University simulator (NYUSIM) using the obtained real-field parameters with changing parameter of temperature and fixed parameter of humidity and barometric pressure to inspect the temperature effects to the 5G Telkom University channel model. Third, we calculate the CDF of received power from set of instantaneous PDP with maximum temperature set of instantaneous PDP minimum temperature. Fourth, we obtain the representative PDP of 5G Telkom University channel model with maksimum and minimum temperature effects. Finally, we obtain the theoretical outage performance by assuming that Shannon capacity is achieved such that channel coding rate R is equal with channel capacity C.

IV. Power Delay Profile Analysis

The 5G channel model is derived based on the representative PDP calculated from thousand instantaneous PDP with 90% CDF percentile, where the power of minimum path is set to -150 dB. Representative PDP of Telkom University 5G channel model is shown in Fig. 2 based on data from BMKG from January 2017 until January 2018.

Bandung city has characteristic of average barometric pressure 1011 mbar, humidity 65%, maximum temperature 37.5^o C and a minimum temperature 17^o C. Representative PDP with minimum temperature $T_{min} = 17^o$ C has 20 paths, meanwhile the total path of representative PDP with maximum temperature $T_{max} = 37.5^o$ C has 18 paths.

V. Outage Performance Analysis

This paper conducts a capacity calculation to observe the CDF of capacity for each representative PDP with maximum and minimum temperature in Rate $R = 1$, $R = 1/2$, and $E_b/N_0 = 0$ dB until $E_b/N_0 = 40$ dB. The outage performance of Telkom University 5G channel model is obtained from the results of taking a value on a particular R for each E_b/N_0.

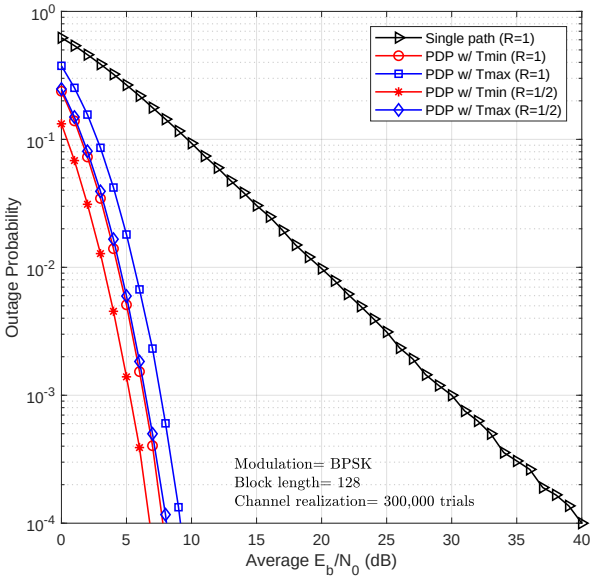


Fig. 3. Outage probability of Telkom University 5G channel model.

Furthermore, the results plotted on the outage probability toward E_b/N_0 as shown in Fig. 3.

Outage probability of PDP with maximum temperature have a performance degradation compared to the PDP with minimum temperature. The causes is partly due to the increase in thermal noise when electronics components in the measurement device to become hot.

The E_b/N_0 gap between outage probability of 10^{-4} with maximum and minimum temperature is 1.5 dB on $R = 1$ and 1.4 dB on $R = 1/2$. These outage performance and E_b/N_0 values are expected to become a reference for 5G system implementation in Telkom University and Indonesia.

VI. Conclusion

This paper has proposed (i) Telkom University 5G channel model considering temperature effects and (ii) a framework to calculate the channel model using a real-field parameters. Computer simulations based on NYUSIM are conducted to produce the representative PDP as the Telkom University 5G channel model considering the temperature effect. The results show that temperature affects on the decrease of the number of the path and worsen outage performance.

References

[1] E. Christy, R. P. Astuti, and K. Anwar, "5g telkom university channel model under foliage effects," in *International Conference on ICT for Rural Development*, Bali, October 2018.

[2] E. M. Alfaroby, N. M. Adriansyah, and K. Anwar, "Study on channel model for indonesia 5g networks," in *2018 International Conference on Signals and Systems (ICSigSys)*, Bali, May 2018.

[3] 3GPP, "Technical specification group radio access network," *document 3GPP TS 38.211*, vol. 1047, December 2017.

[4] KEMEN-KOMINFO, "Berita negara republik indonesia," vol. 1047, July 2017.